Assessing Microbial Mat Erosion Conditions on Earth and Other Planetary Surfaces. K. R. Fisher[1], R. C. Ewing[2], M. Sweeney[3], M. Zawaski[2], M. Tice[2], and M. Nachon[2], [1]NASA Johnson Space Center (Kenton.r.fisher@nasa.gov), [2]Texas A&M University, [3]University of South Dakota.

Introduction: Microbial mats flourished as a dominant lifeform on early Earth and are often considered candidates for life during past habitable periods on other worlds [1]. Microbial mats exist at the surface-fluid interface in sedimentary, which makes them vulnerable to erosion from fluid flows and particle transport [2]. Microbial mats must resist these erosion forces to be buried and preserved. Knowing where to explore when searching for biosignatures on other worlds hinges on our understanding of the stability of these life-hosting surfaces against erosion by wind and water.

Here we compare our measurements of erodibility of microbial mats in wind and water at Padre Island, Texas, with measurements from studies of microbial mat erosion and model erosion environments on other planetary surfaces to assess their potential to erode potential life-hosting sedimentary surfaces.

Methods: Field experiments were conducted on the hypersaline tidal flats at Padre Island. The flats and interdune areas on Padre Island feature many different microbial mat and crust morphologies which frequently experience both aeolian and subaqueous transport conditions. Aeolian erosion thresholds were measured using the Portable In-Situ Wind Erosion Lab (PI-SWERL) and subaqueous erosion thresholds were measured utilizing a cohesive strength meter (CSM)[3]. Erosion thresholds were determined for three different microbial mat types and one salt crust. These thresholds were compared to similar microbial mat erosion measurements conducted by other authors at different locations for both aeolian and subaqueous conditions.

Erosion on Planetary Surfaces: To quantify erosion on other planetary surface, we consider fluid shear and particle impacts. We compared the critical shear thresholds for particle entrainment in both aeolian and subaqueous flows. To assess changes in particle abrasion forces, we utilized the collision Stokes number. The collision Stokes number is a measure of the momentum exchange of an interparticle collision versus the viscous pressure force in the interstitial gap between colliding particles [4]. Abrasion is a result of the energy transfer between colliding grains, which is a function of viscous pressure exerted on the grain by the fluid and the momentum of the colliding particles [5]. The calculation of collision Stokes number for different planetary transport conditions allow for the relative comparison of abrasion.

Results: The field measurements showed that distinct microbial mat morphologies respond differently to

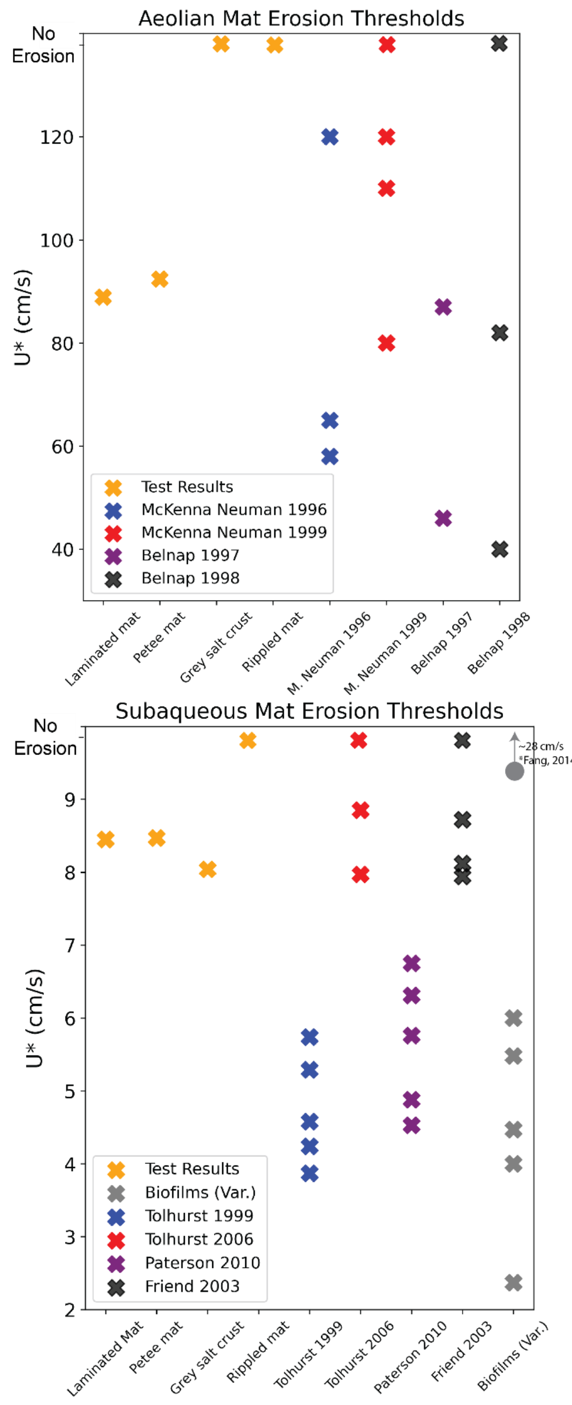

Figure 1. Mat erosion thresholds in aeolian flows (top) and subaqueous flow (bottom) at Padre (yellow) and in literature (other colors).

erosion (Fig. 1). Under aeolian and subaqueous conditions two mat types eroded and one did not. These results were similar to those published by other authors with exception to two subaqueous studies. The u* at which the mats eroded in subaqueous conditions exceeds the flows expected in the field at Padre Island indicating that subaqueous erosion is rare.

The calculations of the collision Stokes numbers revealed significant differences in the abrasiveness across the different planetary environments (Fig. 2). In aeolian conditions, Mars is an order of magnitude more abrasive than Earth. In subaqueous conditions all planetary surfaces have similar collision Stokes numbers, which indicates that erosion by particle impacts is similar in liquid flows on all planets considered.

Discussion: The preservation of microbial mat biosignatures is on the first order a function of the ability of microbial mats to resist erosional forces at the surface. The field measurements show that the erosion response is variable and likely driven by mat morphology. The thicker mats (rippled mats) did not erode in any tests indicating that as mats grow there is likely some threshold after which they are strong enough to resist erosion. The presence of salt likely contributes to the strength of the mats in aeolian settings but is not the dominant force as evidenced by the results of the subaqueous tests.

The modeling results show that the largest variation in abrasion is in aeolian transport settings rather than subaqueous conditions. This is likely due to the vast differences in atmospheric density which can either increase particle impact energy (Mars) or decrease it due to damping (Venus) [6]. It is also important to note that the critical grain size at which abrasion can occur is much higher in subaqueous conditions. This is because the greater fluid density in liquids increases damping in interparticle collisions, decreasing energy transfer and reducing abrasion. This suggests that deposits formed in low energy subaqueous environments with minimal exposure to aeolian transport processes have the highest likelihood for preserving recognizable microbially-induced sedimentary structures.

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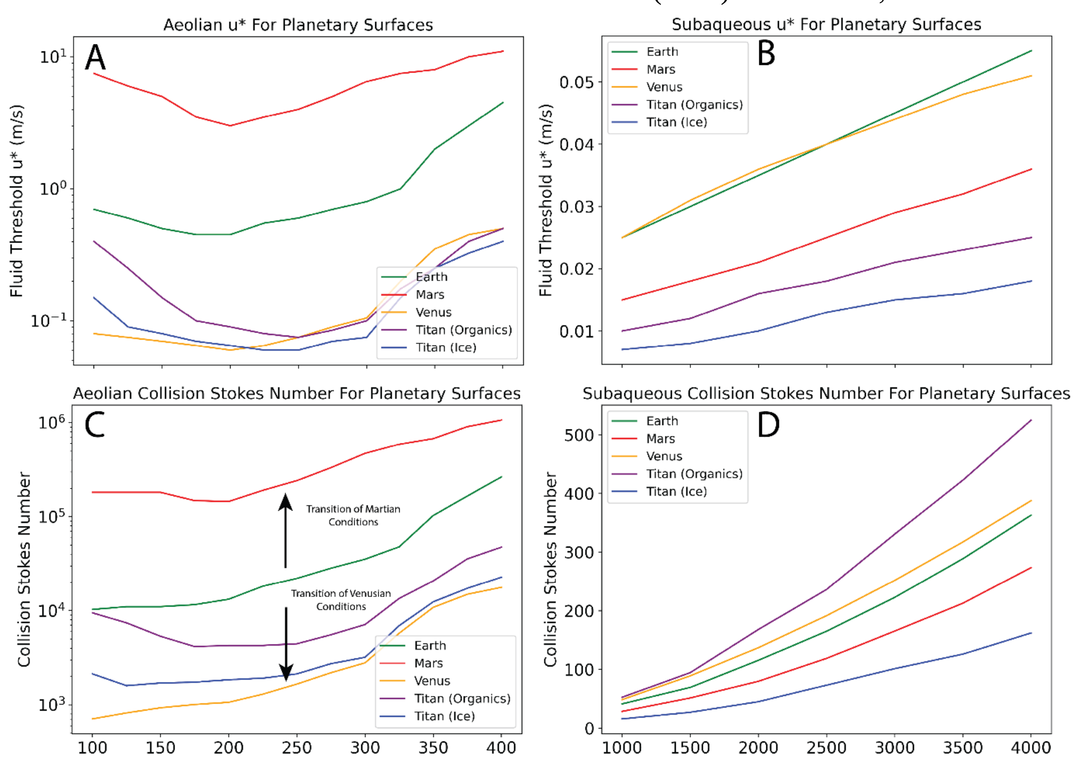

Figure 2. Fluid threshold u* for aeolian (A) and subaqueous (B) transport across Earth, Mars, Venus, Titan (Organics), and Titan (Ice). Collision Stokes numbers for aeolian (C) and subaqueous (D) particle transport across same planetary surfaces. Subaqueous transport on Mars and Venus is assumed for paleoclimatic conditions. Titan values are calculated twice to consider both grain composition scenarios (organics, ice).